the North-West Territories, and from the reports and maps of the scientific men who had accompanied the various Arctic expeditions by sea and land. Specimens and interesting notes on the geology of Great Slave Lake had been received from Capt. H. P. Dawson, R.A., who had spent last year there in charge of the Canadian Station of the Circumpolar Commission. The distribution of the various formations from the oldest to the newest was illustrated by a large geologically-coloured map of the whole Dominion. Referring first to the Laurentian system, Prof. Bell showed that it forms the surface-rock over an enormous area of circular form on the main continent, and that the central part is occupied by the waters of Hudson's Bay, which are surrounded by a border of Palæozoic rocks. If we included the Laurentian rocks of Greenland and the Atlantic coast from Newfoundland to Georgia, it would be observed that their general outline corresponds with that of the continent, which has been built up around this ancient nucleus. The Huronian strata, which constitute the principal metalliferous series in Canada, were closely associated with the Laurentian, and appeared to be always conformable with them. The largest and best-known areas were between Lake Huron and James's Bay, but Dr. Bell had found four belts of them on the east coast of Hudson's Bay, and others had been recognised in the primitive region to the west of it. Indeed wherever the older crystalline rocks had been explored in Canada, belts having the character of the Huronian series had been met with. Limestones, slates, and quartzites, interstratified with amygda loids, basalts, &c., corresponding with the Nipigon formation of Lakes Superior and Nipigon were largely developed on the Eastmain coast and adjacent islands of Hudson's Bay, and apparently also on the Coppermine River and to the westward of it. But a set of hard red siliceous conglomerates and sandstones were seen to come between the Huronian and the Nipigon series at Richmond Gulf on the Eastmain coast, which appeared to be unconformable to both. Mr. Cochrane and Dr. Bell had found similar rocks on Athabasca Lake, Capt. Dawson, R.A., on Great Slave Lake, and Sir John Richardson to the north-east of Great Bear Lake. The conglomerates, slates, and gray argillaceous quartzites of Churchill and the white fine-grained quartzite of Marble Island were probably of this horizon. Silurian rocks were well known to be widely spread on some of the largest of the Arctic islands, and along the most northern channels of the Polar Sea. They formed an irregular and interrupted border on the western side of Hudson's and James's Bays. A large basin of Devonian strata, containing gypsum and clay-ironstone, extended southward from James's Bay. West of the great Laurentian area, Devonian rocks could be traced here and there all the way from Minnesota to the mouth of the Mackenzie River. They were not, however, so widely distributed as had been supposed by the older travellers, who had passed rapidly through the country in the early part of the century, when the whole subject of American geology was in its infancy. The so-called bituminous shale of Sir John Richardson and others, so prevalent along the Athabasca and Mackenzie Rivers, was found by Prof. Bell to consist of soft Cretaceous strata, saturated and blackened by the petroleum rising out of the underlying Devonian rocks, which here, as in Ontario, Ohio, and Pennsylvania, are rich in this substance. The principal features and the geographical distribution of the Carboniferous, Liassic, Cretaceous, and Tertiary rocks of the northern regions were next described. Among other points of interest in reference to the post-Tertiary period, Dr. Bell mentioned that the remains of both the mastodon and mammoth had been found on Hudson's Bay, and that there were reports of the occurrence of elephants' tusks on an island in its northern part. Isolated discoveries of elephantine remains had been made in the North-West Territories and several on the Rat River, a tributary of the Youkon, near the borders of Alaska. In referring to the economic minerals, Prof. Bell said that even the coarser ones, such as granite, limestone, cement-stone, slate, flagstones, gypsum, clays, marls, ochres, sand for glass-making, moulding, &c., would yet have their value in different parts of the great region under consideration. Soapstone, mica, plumbago, asbestos, chromic iron, phosphate of lime, salt, pyrites, &c., had been noted in different localities. Among ornamental stones known to occur, might be mentioned the rare and beautiful mineral lazulite discovered by Dr. Bell at Churchill, also malachite, jade, agate, cornelian, chrysoprase, &c. Lignites of various qualities, some being very good, were found in many places throughout the great tract occupied by the Cretaceous and Tertiary rocks of the Athabasca-Mackenzie Valley and on the coasts and islands of the Arctic Sea; also in Tertiary strata at Cumberland Bay and in Greenland, on the opposite side of Davis' Strait. The lignites found by Dr. Bell on the Albany and Moore Rivers were of post-Tertiary age. Anthracite of fine quality had been found on Long Island in Hudson's Bay. True bituminous coal had been reported to occur on Banks' Land, Melville, and Bathurst Islands. Petroleum, which proceeded from Devonian strata as elsewhere in North America, was very abundant along the Athabasca and Mackenzie Rivers, and vast quantities of asphalt resulting from the drying up of the exuding petroleum were found on the Athabasca, around Great Slave Lake, and at various places in the interior. In reference to the metals, the ores of iron were abundant. Inexhaustible quantities of rich manganiferous carbonate of iron existed on the islands of the Manitounik chain. It lay in beds upon the surface over hundreds of square miles, and was broken up by the frost into pieces of convenient sizes for shipping. Valuable deposits of magnetic iron had been found on Athabasca and Knee Lakes, and a great bed of pure clay-ironstone on the Mattogomi River. Capt. Dawson had found a vein of specular iron on Great Slave Lake. Copper ore had been met with on Hudson's Bay and near Lake Mistassini, and large quantities of the native metal were known to occur on the Coppermine River. A band of limestone, running from Little Whale River to Richmond Gulf, was rich in galena. Zinc, molybdenum, and manganese had been found on Hudson's Bay, and antimony in the north. Both gold and silver had been detected in veins on the Eastmain coast, and alluvial gold had been washed out of the gravel and sand of the streams among the mountains in the tract to the west of the lower part of the Mackenzie River, which Dr. Bell thought might yet become the great gold and silver region of the north, corresponding with Colorado and Nevada to the south. The fine gold-dust found in the drift in one section of the North Saskatchewan may have been derived, during the Glacial period, from the upper valleys of the Liard, on one of which the famous Cassiar gold district is situated; although Dr. Bell had some years ago originated the theory that this gold might have come from Huronian rocks in the district to the north-eastward of Edmonton.—"Note sur certains dépôts aurifères de la Beauce," by the Rev. Prof. Laflamme, D.D.—"Découverte de l'émeraude au Saguenay," by the same. — Description of a supposed new Ammonite from the Upper Cretaceous rocks of Fort St. John on the Peace River, by Prof. J. F. Whiteaves, F.G.S., &c.; On a new Decapod Crustacean from the Pierre Shales of Highwood River, N.W.T., by the same. The Ammonite referred to in the first of these communications appears to be a previously undescribed species of *Prionocyclus*, closely allied to the type of that genus, the *Ammonites woolgari* of Sowerby, but with much more closely coiled volutions. It occurs in flattened nodules, in shales which are believed to be the equivalents of the Fort Benton group of the Upper Missouri section. The Decapod Crustacean from Highwood River, a tributary of the Bow, is doubtfully referred to the genus *Hoploparia* of McCoy.—Notes on the manganese ores of Nova Scotia, by E. Gilpin, M.A., F.G.S.—A revision of the geology of Antigonish County, Nova Scotia, by the Rev. D. Honeyman, D.C.L. —"Notes sur la constitution géologique de l'Apatite Canadienne," by S. Obalski.

THE RAINS AND THE RECENT VOLCANIC ERUPTIONS[1]

THE rains this year have been more persistent than usual. At Perpignan they have been extraordinary. Is it necessary to see any relation between this circumstance and the recent volcanic eruptions? The beautiful crepuscular colorations of the past autumn and winter have been attributed to these eruptions; ought we also to attribute to them the extraordinary spring rains? I should be inclined to believe it. It is acknowledged that the presence in the atmosphere of solid particles facilitates the condensation of vapour. This would be in conformity with the position maintained by Mr. Aitken in his paper on Dust, Fog, and Clouds (volume for 1880-81, *Trans. R.S.E.*). He concludes thus:—"In an atmosphere saturated with vapour, but free from dust, there is formed neither cloud nor fog; whenever the vapour of water is condensed in the atmosphere, it is owing to the presence of those solid particles, each of which becomes, so to speak, a centre of condensation, or the nucleus of a small crystal of ice."

[1] Paper read at the Paris Academy of Sciences by M. Gay, June 23.

Very often direct observation has shown the existence of these dusts in drops of rain, and this is what has happened in all parts of the world since the crepuscular colorations of 1883-84. The dusts collected have a composition which usually indicates a volcanic origin. It has been shown that other volcanic eruptions have been followed by red glows in the sky; it appears to me that it may also be shown that they have been followed by abundant rains. The eruptions which have been referred to are those of the Skaptar Joekull, in Iceland, in the beginning of May 1783; of a new volcano, since disappeared, in the Sicilian Sea early in July 1831; Cotopaxi, in America, in 1856; Vesuvius in 1862. These eruptions were followed by colorations; I add that they were followed by rains which exceeded the mean. The following, in millimetres, are the monthly heights of rain collected on the terrace of the Paris Observatory; the second line is the monthly mean of from twenty to thirty years:—

	May	June	July	Aug.	Sept.	
1783	62	86	43	75	51	
Means	47	49	86	47	42	
	Oct.	Nov.	Dec.	Jan. 1832		
1831	52	76	36	35		
Means	41	47	34	34		
	April	May	June	July	Aug.	Sept.
1856	51	117	49	54	54	60
Means	37	53	54	55	45	48
	Aug.	Sept.	Oct	Nov.	Dec.	
1862	52	51	73	17	42	
Means	45	48	51	36	35	

EXPERIMENTS ON THE PASSAGE OF ELECTRICITY THROUGH GASES—SKETCH OF A THEORY[1]

THE passage of electricity through gases has of late years become a very favourite subject for experimental investigation. A large number of facts have thus been accumulated, and it becomes of importance to see whether these facts throw any light on the theoretical notions which we have based on other branches of electrical inquiry.

If we have two bodies at a different electrical potential separated by a layer of air, we might imagine the air in contact with the bodies to become electrified, then move on, impelled by the electric forces, and re-establish equilibrium by giving up their charges. The passage of electricity through gases would then be similar to the diffusion of heat. But, however natural such a view would be, it is impossible to maintain it in the face of experimental facts. The experiments which I shall bring before you to-day seem to me to support, on the contrary, the idea that the passage of electricity through a gas resembles the phenomenon studied by Helmholtz under the name of electrolytic convection.

I shall avoid as much as possible all suppositions and hypotheses which cannot be put to the test of experiment; but it seems necessary to start with some assumption in order to avoid too great a vagueness in the subsequent explanations. The assumption which I shall make is this: In a gas the passage of electricity from one molecule to another is always accompanied by an interchange of the atoms composing the molecule. I shall also try to prove that many facts are easily explained by the assumption that the molecules are broken up at the negative pole.

If, in a vacuum-tube of the ordinary form, the discharge is passed at a pressure of about one millimetre, a luminosity is seen round the negative pole which is called the negative glow. A luminous tongue projects from the end of the positive pole, which I shall call the positive part of the discharge, without meaning to imply that it is charged with positive electricity. The positive part of the discharge and the negative glow are separated by a non-luminous space, which I shall call "the dark interval." The glow itself is divided into three layers, the thickness of which increases with decreasing density. Closely surrounding the electrode itself, we have in the first place a luminous layer, which on new electrodes is of a golden colour. The spectroscope shows the presence of sodium and hydrogen; the sodium is due to foreign matter deposited on the electrode, and the hydrogen is expelled by the action of the heat out of the electrode by which it had been absorbed. When the electrodes have been in use for some time, the golden colour disappears, and the spectrum belonging to the gas used is seen. The second layer is known by the name of the dark space. The third layer is the glow proper.

The theory which I shall endeavour to establish is this: That within the first layer the gaseous molecules are decomposed, that their negative parts are projected with great velocity through the dark space, that this velocity is gradually reduced by impacts within the glow, and that in the positive part of discharge the discharge takes place by diffusion except when stratifications appear.

According to the kinetic theory of gases, the molecule of mercury vapour consists of a single atom, which is incapable of vibration. Mercury has a very brilliant spectrum, which proves that the theory is incomplete in some important point. It is well known, on the other hand, that the theoretical conclusion receives support from the fact that the vapour-density of mercury vapour is anomalous. If, as is generally supposed, the molecule of the majority of gases contains two atoms, that of mercury can only contain one. If an essential part of the glow discharge is due to the breaking up of the molecules, we might expect mercury vapour to present other and much simpler phenomena than the gases with which we are generally accustomed to work. *This, indeed, is the case; for I find that, if the mercury vapour is sufficiently free from air, the discharge through it shows no negative glow, no dark spaces, and no stratifications.* At the ordinary temperature the spark does not pass through mercury vapour; but if a tube free of air, but containing mercury vapour, is heated, the discharge passes always in a continuous stream of light. It is not always quite symmetrical with respect to the two poles; and a very curious tendency of the spark is noticed, to pass at the negative pole rather from the glass out of which the electrode protrudes than from the metallic electrode itself. A brilliant sodium spectrum then appears at the point from which the spark sets out. Whenever small traces of air remain, stratifications are very apt to appear, as a mixture of air and mercury gives fine stratifications, but I have never noticed them after sufficient removal of the air.

I now pass to the description of an experiment which seems to me to be only capable of explanation by the views brought forward in this paper, and I should like therefore to consider them as crucial experiments, which have to be explained by any true theory of the discharge. As negative electrode, I use an aluminium cylinder of 5·5 cm. internal diameter and 8 cm. long. A long aluminium wire running parallel to the axis of the cylinder at a distance of about an inch formed the positive electrode. On exhaustion, the discharge at first passes as a spark in the ordinary way, but as the pressure decreases the glow gradually surrounds the whole cylinder, *with the exception of a dark strip about 2 or 3 cm. in width, directly opposite the positive wire.* The positive electrode seems, therefore, to repel the negative glow.

The following seems to me a plausible explanation of the phenomenon which I have just described. The rapid fall of potential which is observed on crossing the negative electrode suggests at once, independently of any theory that we have to deal with, the action of a condenser, for we know that no statical charge can produce a finite difference of potential at the electrode, while a double layer will produce a discontinuity. Although it may not be proved that an absolute discontinuity of potential exists at the kathode, it is yet certain that a very rapid fall occurs at that place. This is all that is necessary for the argument.

We recognise such a double layer in the case of electrolytes, but there is an essential difference in the thickness of the layer within which we must imagine that condenser action to take place. In the liquids that thickness must be very small, as is shown by the intensity of the observed polarisation currents. The positively electrified matter in every case is kept against the negative surface by a joint action of electrical and chemical forces, for it has been shown by Helmholtz that only thus can we explain a difference of potential between two bodies. It is the chemical forces which keep the electricities asunder. The gaseous molecules or atoms, however subject to their mutual encounters, and always having certain velocities, will tend to leave the surface. They are kept near the surface, however, by the electrical forces.

Suppose, now, that a positive electrode is placed near such a condenser. The resistance of the gas is so much greater than that of the metal electrode that we shall assume the whole elec-

[1] Abstract of the Bakerian Lecture. Read before the Royal Society, June 19, 1884, by Arthur Schuster, Ph.D., F.R.S.